DUPONT®

Elvamide®

nylon multipolymer resins

Start with DuPont

General Description

DuPont Elvamide® nylon multipolymer resins are a family of unique polymers having outstanding abrasion resistance, high tensile strength and elongation, and excellent adhesion to nylon yarns.

The three grades most frequently used in thread bonding provide a broad range of properties to achieve optimum performance for a variety of sewing thread applications. The grades can be used separately or in combination. Usually they are applied from solvents. Plasticizers and modifiers are sometimes used to provide specific properties.

This technical bulletin provides information on the use of Elvamide® for nylon thread bonding applications. The information may be useful for other textile industry applications.

Advantages of Thread Bonding and Benefits of DuPont Elvamide® *

Bonded sewing thread provides advantages as follows:

- Bonding results in higher sewing rates and less downtime to reduce labor and production costs on sewing machines.
- Applicable to multicord and monocord, bonding potentially reduces twisting costs for thread because it permits low twist without sacrificing thread performance.
- In heavy sewing applications, bonding provides greater abrasion resistance and threads take a more permanent set with less tendency to ravel than “soft” or unbonded threads.
- Bonding simplifies inventory by permitting the same direction twist, to replace conventional left- and right-handed twist unbonded sewing thread required on twin needle sewing machines.

DuPont, with years of experience in polyamide technology, is a major producer of alcohol soluble multipolymer nylon resins. Important benefits of DuPont Elvamide® are:

- Excellent adhesion to nylon yarn
- Readily applied from solutions in low cost, quick evaporating alcohols
- High melting point prevents “gumming-up” at high needle temperatures frequently encountered in high speed sewing
- Economical in use. Only 4 to 10% Elvamide® is required to give excellent bonding
- Consistent quality

Elvamide® Grades and Physical Properties

Three grades of Elvamide® are offered which include most properties desired in thread bonding operations. These grades are listed below and in **Table 1**, which presents their physical properties.

- Elvamide® 8061 is generally preferred. It has high tensile strength, good abrasion resistance and high flexibility.
- Elvamide® 8063 is a more gel-resistant resin than Elvamide® 8061. It is preferred for solutions that must be stored or shipped.
- Elvamide® 8023R dissolves faster, gives lower viscosity solutions and permits higher concentrations than other grades.

A fourth grade, Elvamide® 8066, is less soluble in alcohols. It is used primarily in fabric bonding applications.

Elvamide® resins are shipped in moisture-barrier bags. If Elvamide® is to be used where moisture can be a problem, care should be taken once the bag is opened to avoid exposure to high humidity. On the other hand, moisture may contribute to ease in solution preparation. In this case, the nylon cubes can be submerged in water overnight. Upon prolonged immersion, Elvamide® will absorb over 20% water; the absorbed water plasticizes Elvamide®.

Table 1
Physical Properties of Elvamide® Nylon Resins

Typical Properties	ASTM Method	Elvamide® 8023R	Elvamide® 8061	Elvamide® 8063
Form and Color	—	1/8″ white, transparent spheres	1/8″ white, transparent cubes	1/8″ white, transparent spheres
Moisture Content, %	—	0–5.0	0–0.7	0–0.7
Melting Point, °C (°F)	D3418	154 (309)	156 (313)	158 (316)
Specific Gravity	D792	1.07	1.08	1.08
Tensile Strength*, MPa (psi) 23°C (73°F)	D638	51.0 (7,400)	51.4 (7,500)	51.7 (7,500)
Elongation at Break*, % 23°C (73°F)	D638	370	320	315
Flexural Modulus* MPa (psi)	D790	490 (71,000)	952 (138,000)	903 (131,000)
Characteristics	—	For special high solids solutions	General purpose; combines good solubility, abrasion resistance and toughness	Greater gel resistance

*Samples conditioned in equilibrium with atmosphere and 50% RH.

Specifications

Because consistent solution viscosity is so important in thread bonding, DuPont controls relative viscosity for each grade of Elvamide® to the following specifications:

Elvamide® Grade	Relative Viscosity*
8023R	24–36
8061	70–100
8063	70–100

*See procedure under Test Methods

Chemical Properties

Elvamide® nylon multipolymer resins are insoluble in water. They resist hot or cold aqueous alkali and most salt solutions. Acetic acid affects Elvamide® slowly; stronger acids affect it more rapidly. Strong oxidizing agents react with Elvamide®, but air, oxygen and ozone do not unless prolonged elevated temperatures are encountered.

Elvamide® resins are highly resistant to petroleum products, such as lubricating oils and greases; aliphatic and aromatic hydrocarbon solvents and fuels. Elvamide® resins also resist many organic solvents, including most lacquer solvents, dry cleaning fluids, carbon disulfide, ketones, esters, and amides. They also resist most plasticizers used in polyvinyl chloride plastics.

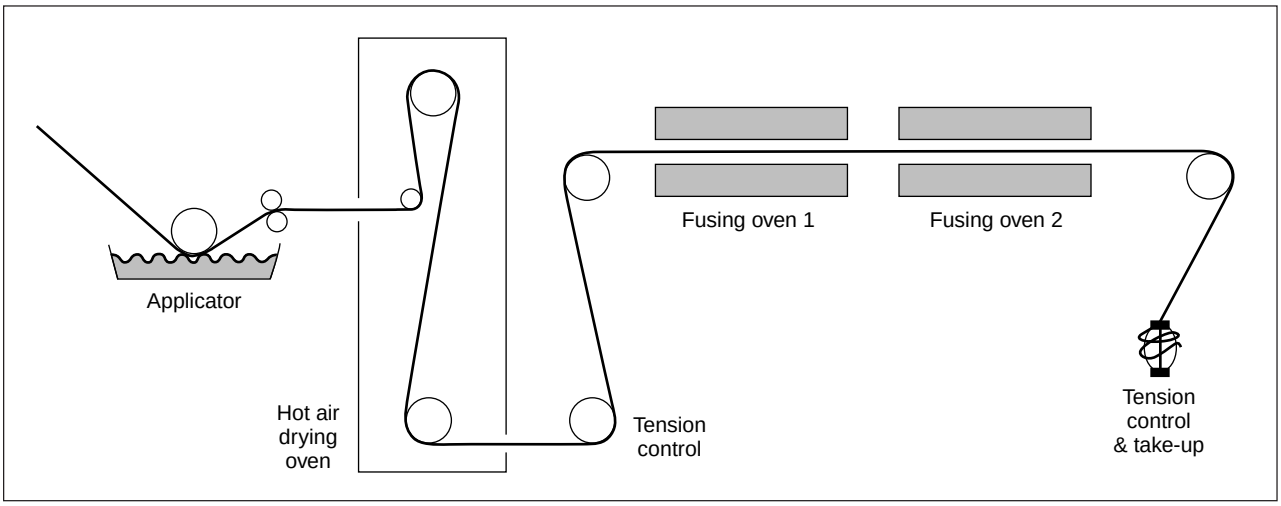
Elvamide® nylon resins can be crosslinked with epoxy, melamine and phenol formaldehyde resins.

Thread Processing

Elvamide® nylon resin is usually applied to the thread from a solvent solution of 4–18% solids in a dip trough. (See **Figure 1** for a schematic diagram of the thread bonding process.) The trough should include automatic level controls; covers and seals to prevent evaporation loss and temperature controls to prevent viscosity change. Usually a minimum of 3 to 5% Elvamide® (based on thread weight) must be coated on multicord or monocord for satisfactory results. Increasing levels of Elvamide® improve bonding, but a desired balance between thread bonding and stiffness must be arrived at by the processor. Typical relationships of percent pick-up of Elvamide® versus bonding performance and thread stiffness are shown in **Table 7** for Type 69 nylon thread.

After coating thread with a solution of Elvamide®, the excess is removed and the thread is dried to remove solvent; if residual solvent remains, blisters may be formed in the subsequent fusing step. Drying is usually accomplished with air at temperatures above 107°C (225°F). If water is present in the solvent, additional heat may be required. Caution must be exercised to prevent a flammable concentration of solvent from collecting in the air stream.

Figure 1. Thread Bonding Schematic



Following solvent removal, the thread temperature is raised above 160°C (320°F) to fuse the resin to the thread.* The nylon thread is heat-set in this step and the desired elongation is achieved.

Appropriate thread finishes are next applied to the thread to impart subsequent processing properties. The thread is then wound on pirns and finally rewound on spools for packaging.

Solvent Selection

Selection of a solvent or solvent system for formulating and applying Elvamide® is important and depends on balancing:

- desired solids level
- solution viscosity
- solution stability
- type and size of thread
- thread processing equipment and heat source
- fire and toxicity hazards
- environmental factors

For thread bonding applications, the solvents most commonly used for Elvamide® resins are: methanol, ethanol and propanol as well as blends of these with water.

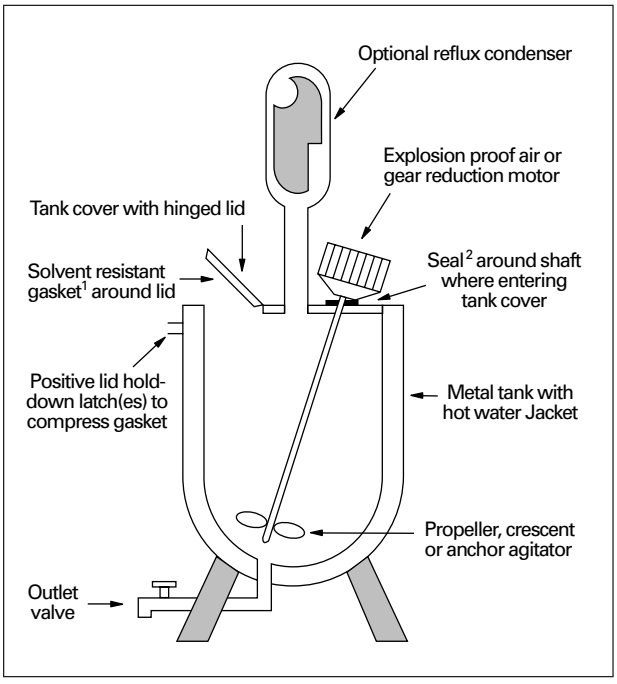
Methanol is generally the most effective solvent and will dissolve 20% (by wt) Elvamide® with mild heating. Methanol solutions are lower in viscosity at a given solids level than the higher alcohols.

Comparative data for commonly used solvents for Elvamide® 8063, 8061, and 8023R are shown in **Tables 2**, **3**, and **4**, respectively.

Solution Preparation

For suggested preparation equipment, see **Figure 2**. The use of a reflux condenser is desirable. Explosion-proof electric or air motor agitator drives are adequate for most operations.

Figure 2. Equipment for Preparing Solutions



NOTE: Add ventilation over tanks as necessary to remove fumes from work areas. All metal parts should be grounded according to applicable codes and practices for handling flammable solvents.

[1] Suggested materials include Nordel® synthetic rubber or other materials recommended by gasket suppliers as suitable for use with methanol or other alcohol.

[2] Seals of Teflon®, fluorocarbon resin or other materials recommended by their suppliers as suitable for use with methanol, etc.

*See Table 7 for effect of oven temperature on performance.

Table 2
Solution Stability of Elvamide® 8063

Parts (wt)	Solvent Composition	Brookfield Viscosity, mPa·s (cP) 10% Solids	Brookfield Viscosity, mPa·s (cP) 20% Solids	Gelation, days 10% Solids	Gelation, days 20% Solids
100	Methanol	14	155	30–31	<1
85/15	Methanol/Water	21	253	30–31	25–26
90/10	Ethanol/Water	37	—	<1	—
80/20	Ethanol/Water	42	730	25–26	25–26[a]
100	SDA[b] #30 alcohol, 200 proof	28	gel	2–3	1 hr
100	SDA #2B, 190 proof	36	578	25–26	<1

[a] Solution cloudy but remains fluid.
[b] See Chemical Handbook for SDA (specially denatured alcohol) formulas.

Table 3
Solution Stability of Elvamide® 8061

Parts (wt)	Solvent Composition	Brookfield Viscosity, mPa·s (cP)[a] 10% Solids	Brookfield Viscosity, mPa·s (cP)[a] 20% Solids	Gelation, days[a] 10% Solids	Gelation, days[a] 20% Solids
100	Methanol	30	280	10[b]	3
85/15	Methanol/Water	39	610	10–11	6
90/10	Ethanol/Water	103	1,860	10–11	6
80/20	Ethanol/Water	111	1,960	10–11	6
100	1-Propanol	66	—	2	—
90/10	1-Propanol/water	76	—	10	2

[a] Stability (gelation) tests and viscosity measurements were made at 25°C (77°F).
[b] Solution cloudy but still mobile.

Table 4
Solution Viscosity of Elvamide® 8023R

Methanol/Water Parts by Wt	Solids %	Brookfield Viscosity, mPa·s (cP)[a]
85/15	20	130
80/20	20	140
80/20	30	1,030

[a] Measured at 25°C (77°F) with model LVT, #1 spindle.

For solutions of Elvamide® resins up to 20% solids, the resin cubes should be added to the solvent with continuous stirring. The mixture should be heated (no open flame) with continued stirring to a temperature that is 5–10°C (9–18°F) below the reflux point of the solvent or solvent mixture. Usual temperatures are 54–60°C (130–140°F).

Heating and stirring should continue for at least one hour after solution appears complete to ensure that all particles have dissolved. Solvent swollen resin particles are colorless and transparent and consequently difficult to detect.

The time required to dissolve Elvamide® depends on solvent type, resin concentration, resin cube size, and type of agitation. Elvamide® 8023R and 8063 are spherical shapes, requiring somewhat longer dissolution. Typical solution times are summarized in **Table 8**.

Where solvent solutions are stored or handled, adequate ventilation should be provided. See the section on Special Safety Precautions in this technical bulletin. Detailed information on safe handling of solvents can be obtained from the Manufacturing Chemists Association, Inc. or from a solvent supplier.

Prepared solutions of Elvamide® in various alcohol systems are available from several custom formulators. For information contact your DuPont representative (see back cover).

Dispersions of Elvamide® in water at 10% solids are available from General Plastics Corp., a division of PMC, Inc., 55 LaFrance Ave., Bloomfield, NJ 07003.

Typical Stability

On prolonged storage at room temperature or below, solutions of Elvamide® may show clouding or gelation; solution stability is increased as the temperature increases. Gelled solutions can be restored by gentle heating (no open flame) and stirring prior to use.

In alcohol-water solvent systems, the intermolecular nylon hydrogen bonding is reduced and thereby decreases solution time and the tendency for gel formation.

Stability of Elvamide® 8061 in alcohol/water mixtures can be improved by the addition of small amounts of benzyl alcohol or other high-boiling solvents (see **Table 5**). With multicomponent solvent systems the boiling point of any azeotrope should be considered.

As shown in **Tables 2** and **3**, Elvamide® 8063 gives lower viscosity for a given solids content than Elvamide® 8061 and is more gel resistant.

Methanol solutions containing 40 wt% Elvamide® 8061 should be used promptly as gelation occurs in less than 3 hr at 25°C (77°F). At 50% solids, the maximum stability is reduced to 30 min.

Elvamide® 8023R gives the lowest viscosity solutions and is preferred where high solids are required. At least 30% can be dissolved readily in alcohol/water mixtures by stirring at 45–60°C (113–140°F) for approximately 1 hr. **Table 4** shows typical solution viscosities. After two weeks at room temperature, the 30% solids solution increased in viscosity but had not gelled.

Table 5
Stability Improvement with High Boiling Solvents

High Boiling Solvent	Amount, %	15% Solids Elvamide® 8061 Nylon Multipolymer Resin	
		70/30 Ethanol/Water	80/20 Ethanol/Water
		Time Before Gelation, Days (23°C [73°F])	
None	—	1	7
Benzyl Alcohol	5	16	26
Furfuryl Alcohol	5	4	26
m-Cresol	5	4	15

Formulating Elvamide® Nylon Resins

Elvamide® resin grades can be formulated with each other or with modifiers to produce a variety of properties. Generally, modifiers are used with Elvamide® to improve adhesion to specific substrates, to vary blend toughness and flexibility, or for an optimum balance between cost and performance.

Typical modifiers for Elvamide® include plasticizers and thermosetting resins. **Table 6** is a listing of some modifiers compatible with Elvamide® resins.

Plasticizer choice depends on softening performance, cost, and compatibility with Elvamide® nylon multipolymer resins. Solvent sensitivity, processing behavior and low temperature behavior should also be considered. Typically, plasticized Elvamide® will have lower modulus and tensile strength with higher ultimate elongation. Melting point of Elvamide® decreases by an amount related to the mole fraction of the plasticizer added. Because the nylon fiber contributes most of the stiffness to bonded thread, results of stiffness tests on unsupported plasticized Elvamide® cannot be extrapolated.

DuPont data show a definite decrease in stiffness with decreased oven drying temperature (see **Table 7**). For example, 10% solids Elvamide® 8063, when applied from 85/15 wt% methanol/water solutions to Type 69 nylon thread and dried at 163–204°C (325–400°F) exhibits 8% lower thread stiffness compared with 28°C (50°F) higher drying temperatures of 191–232°C (375–450°F). When 5% solids were used, thread stiffness decreased approximately 31% at a 28°C (50°F) lower temperature.

Table 6
Typical Modifiers Compatible with Elvamide®

Plasticizers	
Glycols	Ethylene glycol 2-Ethyl-1,3-hexanediol
Phenols	Octyl phenol Resorcinol Bisphenol A[1]
Sulfonamides	n-butyl benzene sulfonamide[2,7]
Thermosetting Resins	
Epoxy	Araldite[3] Derakane[1] Epon[4]
Melamine/ Formaldehyde	Cymel[5] Resimene[6]

[1]Dow Chemical Co.
[2]Unitex Corp.
[3]Ciba-Geigy Corp.
[4]Shell Chemical Co.
[5]Cytec Industries
[6]Solutia Inc.
[7]Proviron Fine Chemicals

Table 7
Thread Bonding Data*

Resin Type	Solution Percent Solids	Temperature Oven 1 °C	Oven 1 °F	Oven 2 °C	Oven 2 °F	Stiffness Grams[4]	Fingernail Adhesion[5]	Scissor Snip[6]	Bond Strength[7]
Elvamide® 8063	10	163	325	204	400	16.8	E	E	E
8063	5	163	325	204	400	11.2	E	E	G
8063[1]	10	163	325	204	400	13.6	E	E	G
8063	10	191	375	232	450	18.3	E	E	E
8063	5	191	375	232	450	16.2	E	E	G
8063/HD[2]	10	163	325	204	400	15.5	E	E	E
8063/HD	5	163	325	204	400	11.4	E	E	G
8063/BA[3]	10	163	325	204	400	16.3	E	E	E
8063/BA	5	163	325	204	400	9.9	E	E	G
Control	0	163	325	204	400	0.4	NA[8]	P	NA

*All solutions were prepared with 85/15 (methanol/water) except where noted. Thread was run at 18 m per min (20 yd per min). Nominal pick-up from 10% solids = 8%; nominal % pick-up from 5% solids = 4%.

[1] Elvamide® 8063 in 100% methanol.

[2] 2-Ethyl-1,3-hexanediol, 20% based on Elvamide® 8063.

[3] Bisphenol A, 20% based on Elvamide® 8063.

[4] Copies of the developmental procedure used for these tests are available on request.

[5] Fingernail Adhesion: Thread passed between thumb and forefinger removes coating = poor (P); does not remove coating = excellent (E).

[6] Scissor Snip: Does not fray when snipped = excellent (E); easily frayed when snipped = poor (P).

[7] Bond Strength: Resistance to separation of individual plies after twisting, turning and pulling; easy separation = poor (P); some separation = good (G); no separation = excellent (E).

[8] NA: Not applicable.

Table 7 shows reduction in stiffness as a function of solvent. Applying 10% solids solution of Elvamide® 8063 from 100% methanol reduces thread stiffness about 20% compared with 85% methanol/15% water.

The concentration of Elvamide® used in the bonding solution influences thread stiffness—higher concentrations give higher thread stiffness.

Thermosetting or crosslinking resins of the phenol or melamine/formaldehyde type are frequently used as modifiers (see **Table 6** for examples). Elvamide® reacts with these resins at curing temperatures to produce hybrid thermoset-thermoplastic compositions. The effect of using these modifiers is to insolubilize and harden the thread coating.

Decreasing twist per unit length of thread decreases stiffness and reduces cost for power and labor.

Table 8
Typical Solution Times

Solvent (wt%)	Temperature, °C (°F)	Solution Time, hr
Elvamide® 8061		
100 methanol	57 (135)	2
100 methanol	39 (103)	4.5–5
80/20 methanol/water	42 (107)	3
70/30 methanol/water	44 (112)	3
100 2-propanol	71 (160)	insoluble after 3 hr
80/20 2-propanol/water	71 (160)	2.75
Prewet[a] Elvamide® 8061		
100 methanol	39 (103)	4
Predried[b] Elvamide® 8061		
100 methanol	39 (103)	5.5–6
Elvamide® 8063		
100 methanol	39 (103)	3

NOTE: All solutions contained 8% solids.

[a] Elvamide® 8061 was prewet by soaking in water at 39°C (103°F) for 16 hr.

[b] Elvamide® 8061 was predried for 7 days in a vacuum dessicator.

Special Safety Precautions

When preparing solutions of Elvamide® nylon resins in flammable solvents, precautions must be taken to avoid ignition of flammable vapors by static electricity, during the transfer of the resin to a dissolving kettle.

All metal parts of the mixing and processing equipment must be grounded. In addition, precautions must be taken to avoid discharging the static charges which may be generated within the bags of Elvamide® (which are lined with Surlyn® ionomer resin) or on the operator during the transfer operation. It is not recommended that Elvamide® be transferred from the bag directly to the blend tank unless the resin has previously been wet down with water.

Some suggested alternatives for minimizing the hazard are:

- Transfer Elvamide® from the bag to an unlined metal container at a location away from the flammable vapor area. Ground the container to the blend tank. Then transfer Elvamide® from this container to the blend tank using a metal funnel which is grounded to the tank. The free fall distance for the resin should be minimized.
- Mount a grounded metal funnel or trough above the blend tank. The cubes of Elvamide® should travel for at least several feet along the metal surface. The point where Elvamide® is transferred from the bag to the funnel or trough should be well ventilated to reduce the concentration of flammable vapors. With floor-level tank openings, a grounded metal tray may be used.

After pouring Elvamide® from a bag, the operator should ground himself in a safe location before he approaches the potentially flammable environment near the opening of the blend tank.

Operations involving solvents must be adequately ventilated to limit operator exposure to permissible levels. Reference should be made to Section 1910.1000 of Title 29, Code of Federal Regulations, and to the Threshold Limit Values (TLV) published by the American Conference of Governmental Industrial Hygienists for guidance or acceptable concentrations of solvent vapors in the workplace atmosphere. Protect eyes and skin from contact with solvents by using goggles, gloves and other protective equipment.

These suggestions are not intended to be all inclusive. They should be supplemented by good manufacturing procedures, prevailing industry standards and the recommendations of the equipment manufacturers. In any operation that involves the handling of flammable solvents, the utmost care should be taken to avoid static accumulation and other possible ignition sources.

Test Methods for Elvamide® Resins

Nylon resins can be distinguished from other plastics by a simple burning test. Place a small piece of the resin in a "Pyrex" tube and heat the end of the tube gently with a small flame until the polymer has partially melted and some decomposition has occurred. Scorched nylon gives off an unmistakable odor similar to that of burning hair.

Shown below are test methods for Elvamide®, the most important of which is relative viscosity.

Relative Viscosity

Relative viscosity is a calculated value of the ratio of absolute solution viscosity to the absolute viscosity of the solvent. It is measured for an 8.4 wt% solution of Elvamide® resin in 90% formic acid solvent (0.11 g resin/ml formic acid). The absolute viscosity of formic acid is determined using a Cannon-Fenske size 75 viscometer. A Brookfield Viscometer is used to determine the absolute viscosity of the Elvamide® formic acid solution. The spindle and speed should be selected to give a viscosity highest on the 100 scale. Viscosities should be determined at 25°C (77°F).

Melting Point

Differential Thermal Analysis is now being used to determine the melting point of DuPont Elvamide® resins. The DuPont Thermal Analyst 2000/2100 System provides measurement of changes in physical properties of materials as a function of temperature. Test method ASTM D3418, second melt, is used.

Packaging

Elvamide® nylon resins are supplied as approximately 1/8 in colorless transparent cubes. They are packaged in 25 kg (55 lb) net moisture barrier paper bags which maintain extremely low moisture levels.

FDA Status

Elvamide® 8023R, 8061, and 8063 comply with FDA Regulation 21 CFR178.2010, "Antioxidants and/or Stabilizers for Polymers," for use only at levels not to exceed 1.5% by weight of polyoxymethylene homopolymer as provided in paragraph (b) (1) of Regulation 177.2480 entitled "Polyoxymethylene Homopolymers." Elvamide® is not cleared for other uses at this time.

Results of animal studies with Elvamide® 8061 nylon resin show there was no clinical, nutritional, biochemical, or pathological evidence of toxicity when animals were fed at a dietary level of 10%.

NOTES

Identity and Trademark Standards

Guidelines for Customer Use—Joint ventures and authorized resellers

Only joint ventures and resellers who have signed special agreements with DuPont to resell DuPont products in their original form and/or packaging are authorized to use the Oval trademark, subject to the approval of an External Affairs representative.

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All other customer usage is limited to a product signature arrangement, using Times Roman typography, that allows mention of DuPont products that serve as ingredients in the customer's products. In this signature, the phrase, "Only by DuPont" follows the product name.

Elvamide® Only by DuPont or Elvamide®
Only by DuPont

A registration notice ® or an asterisk referencing the registration is required. In text, "Only by DuPont" may follow the product name on the same line, separated by two letter-spaces (see above example). When a DuPont product name is used in text, a ® or a reference by use of an asterisk must follow the product name. For example, "This product contains quality DuPont Elvamide® nylon multipolymer resin to reduce fraying and breaking."

*Elvamide® is a DuPont registered trademark.

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nylon multipolymer resins

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